Rulemaking No.: 13-12-010
Exhibit No.:
Witness: Dr. Karl Meeusen

Order Instituting Rulemaking to Integrate and Refine Procurement Policies and Consider Long-Term Procurement Plans.

Rulemaking 13-12-010

**PHASE I.A. DIRECT TESTIMONY OF DR. KARL MEEUSEN**
**ON BEHALF OF THE**
**CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION**

**BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA**

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| Order Instituting Rulemaking to Integrate and Refine Procurement Policies and Consider Long-Term Procurement Plans. | Rulemaking 13-12-010 |

# PHASE I.A. DIRECT TESTIMONY OF DR. KARL MEEUSEN ON BEHALF OF THE CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

## I. BACKGROUND AND TESTIMONY SUMMARY

**Q. What is your name and who is your employer?**

**A.** My name is Dr. Karl Meeusen. I am employed by the California Independent System Operator Corporation (CAISO), 250 Outcropping Way, Folsom, California. I currently work in the CAISO's Markets and Infrastructure Policy group as the Market Design and Regulatory Policy Lead, a position I have held since 2011.

**Q. Please describe your professional and employment background.**

**A.** Prior to joining the CAISO, I served as Energy Advisor to CPUC President Michael Peevey, advising on issues such as resource adequacy, long-term resource procurement, demand response, and Federal Energy Regulatory Commission (FERC) related issues. I also worked as a Public Utility Regulatory Analyst in the Energy Division of the CPUC as the lead analyst on demand response and FERC related issues. Prior to joining the CPUC, I held research positions at the National Regulatory Research Institute and the U.S. Department of Justice, Antitrust Division and worked as an independent consultant. I hold a Ph.D. in Agricultural, Environmental, and Development Economics from The Ohio State University and a Bachelor's of Science in Philosophy and Economics from the State University of New York, College at Brockport.

**Q. What are your job responsibilities?**

**A.** My primary responsibilities include developing and evaluating new wholesale electricity market designs related to the CAISO's ongoing efforts to integrate renewable resources into the CAISO electricity market and electric grid. This includes assessing changing resource adequacy needs as a result of the increased penetration of renewable resources to ensure that sufficient flexible capacity resources are available to effectively integrate resources. I also represent the CAISO in several other CPUC proceedings, including the resource adequacy proceeding and the joint reliability framework, and am leading the CAISO studies on shorter-term flexibility requirements in the multi-year proceedings.

**Q. Are you familiar with the CAISO's system flexibility studies addressed in Dr. Liu's initial testimony?**

**A.** Yes, I am. Although I did not directly participate in the modeling, creation of the input assumptions, or running of the studies, I am very familiar with how the studies were conducted and what each renewable portfolio scenario demonstrates about long-term system flexibility needs.

**Q. Have you conducted any flexible capacity studies?**

**A.** As the lead analyst on the shorter term multi-year flexibility studies the CAISO is conducting for the resource adequacy proceeding, I am responsible for determining the CAISO's flexible capacity needs for the upcoming resource adequacy year. Those studies are based on the similar input assumptions used in this case. As the CAISO lead analyst for the Flexible Resource Adequacy Criteria and Must Offer Obligation (FRACMOO), I was responsible for designing the study methodology the CAISO uses to determine its each year's flexible capacity resource adequacy need.

**Q. What is the purpose of your testimony?**

A. The scope of testimony for Phase 1a was set out in the May 6 Scoping Ruling and the ALJ's June 2 scheduling ruling. In particular, the rulings request the parties to evaluate whether there is a need for additional flexible resources to meet operational flexibility through 2024, and whether additional system resources are required to meet grid reliability needs through 2024.

As described by witness Dr. Shucheng Liu, the CAISO conducted deterministic flexibility studies using, among other things, the assumptions and scenarios specified in the May 14, 2014 Assigned Commissioner's ruling. His testimony discusses in detail the input assumptions, study methodology, and study results. My testimony (1) explains the conclusions that should be drawn from the flexibility study results, (2) discusses the public policy implications of the results, and (3) recommends actions for the Commission to consider in Phases 1a and 1b.

**Q. Please summarize conclusions and recommendations based on CAISO studies performed for Phase 1a.**

A. 1) The CAISO studies to date are not sufficient, by themselves, to determine the additional capacity needed to meet flexibility and reliability requirements.

2) The CAISO results show a significant amount of renewable curtailment because the studies assumed unlimited renewable curtailment of the renewable resources identified in table 11 of Dr. Liu's testimony. This may be masking the need for flexible capacity because it allows renewable curtailment as the solution to provide flexibility and mitigate over-generation. Without additional studies, it is not possible to identify the specific flexible capacity shortfall that is leading to the curtailment of renewable resources, or if curtailment of renewable resources is the optimal solution to flexible capacity shortfalls.

3) The Commission needs to examine, in phase 1b, the benefits and trade-offs between meeting state policy goals and alternative solutions to meeting any observed flexibility shortfalls. To analyze all of the trade-offs effectively, the CAISO proposes to conduct at least two other studies. One study will book end the effect of having no renewable curtailment and the other can explore a moderate level of curtailment as opposed to the curtailment capability currently assumed in the studies.

4) There are many possible solutions to address system capacity needs. The Commission needs to establish priorities that strike an appropriate balance between the needed mix of resources and state policy objectives. As such, in Phase 1b the Commission needs to examine the extent to which we should rely on renewable curtailment to meet flexibility needs and RPS mandates, and then reconcile these priorities with curtailment provisions in power purchase agreements.

## II. THE CAISO'S STUDIES SHOW THAT THERE ARE FLEXIBILITY NEEDS IN ADDITION TO CAPACITY SHORTFALLS.

**Q. Please describe the capacity (MW) shortfalls shown in the CAISO's study results.**

A. In the deterministic models conducted by Dr. Liu, the CAISO identified capacity deficiencies in all but one of the scenarios and sensitivities tested. The most notable of these capacity shortfalls is that in the High-Load scenario, where we see a 5,353 MW capacity shortage. The Trajectory scenario shows a more limited capacity shortage of 1,489 MW, which is virtually all attributable to a load following up shortfall. The Expanded Preferred Resource scenario shows that there is no capacity shortfall.

Each of the capacity shortfalls identified were for upward capacity needs. Because the CAISO assumed unlimited economic curtailment of grid-connected renewables

identified in table 11 of Dr. Liu's testimony in each of the scenarios and sensitivities, no specific flexibility shortages could be identified. The observed curtailments of renewable resources may, therefore, be best read as a need for flexibility products. These curtailments may also be masking the need for downward, upward or commitment flexibility. For example, two possible causes of a curtailment include downward ramping constraints and upward ramping constraints. In the first instance, the CAISO may need to curtail renewable output because the resources on-line at that time cannot ramp down as quickly as the renewable resources are ramping up. In the latter instance, the CAISO may need to curtail renewable output to ensure it has a portfolio of resources available to address an impending ramp that may be amplified by the renewable resource output declining due to the sun setting. I discuss this issue in more detail later in my testimony. However, based on the current results it is not possible to identify which of these specific needs causes the curtailment without additional studies using different assumptions with respect to renewable resource curtailment.

The Expanded Preferred Resource scenario presents an interesting case in which the load assumptions are equivalent to the trajectory need but it is shaped by the introduction of additional MWs behind the meter small solar PV. The lack of a finding for need should not be a conclusive finding in the context of the curtailability assumption we adopted in this phase. As noted above, his assumption could be masking 1) the lack of downward flexibility that may be needed during times of high curtailment of on-grid renewables as reflected in Table 18 of Dr. Liu's testimony and 2) an upward flexibility shortage in the hours that we did not observe renewable curtailment. This scenario in fact presents a risk to be managed with the increased penetration of small solar PV without the availability of downward flexibility.

**Q. What conclusions can be drawn from comparing these capacity shortfall levels?**

A. The 40 Percent RPS scenario had a 2,242 MW deficiency affecting load following and non-spinning reserves while the Trajectory case had a 1,489 MW shortfall affecting load following and non-spinning reserves. The High Load scenario had 5,353 MW of upward shortage affecting load following, spinning and non-spinning reserve as well as affected small energy shortfall. The difference between these outcomes is a result of the magnitude of the upward shortage.

**Q. How will the Track 1 and 4 resource procurement impact the capacity shortfalls you discuss above?**

A. As Dr. Liu explains in his testimony, the CAISO did not model 2,315 MW of approved capacity additions from LTPP R.12-03-014, Track 1 and Track 4. Without additional studies that include these resources, it is not possible to determine the impact this additional capacity would have on the need for system or flexible capacity. Based on the upward capacity shortfalls identified in the scenarios as studied thus far it seems likely that the authorized procurement would reduce and possibly eliminate the magnitude of the upward shortages. However, while the additional capacity from Tracks 1 and 4 is greater than the overall deficiency identified in the Trajectory and the 40 Percent RPS scenarios, it is not clear if the additional capacity could avoid shortfalls in load following, non-spinning and spinning reserves, and regulation in these or any other scenario tested.

**Q. Should the Commission's inquiry as to the need for additional flexible capacity end with the level of capacity shortfall observed in the scenarios?**

A. No. Capacity shortfalls are just one measure of system need. For example, flexible capacity should not simply be a measure of whether or not the CAISO can follow load. The need for flexible capacity should also consider the portion of a resource available for dispatch and the amount a resource's minimum operating levels may increase the probability of over-generation at certain times and under certain

circumstances. This is a key operational consideration the CAISO must consider at all times.

**Q. Please explain this operational concern.**

A. The scenario results show that in spring months, wind and solar resources start to taper off in the mid afternoon. As shown in the CAISO's "Duck Chart" (attached to this testimony), the CAISO will have to address significant net load ramps that are forecasted to exceed 13,000 MW by 2020. In order to have resources set at a position to meet this ramp, the CAISO may be required to turn on or keep on dispatchable conventional resources at their minimum operating limiting, PMin, in preparation for this ramp. The CAISO refers to the PMin that comes with the flexible capacity as the "PMin burden". In short, this is the PMin the CAISO must accept to get access to flexible capacity from a resource. The larger the PMin burden is as a portion of resources needed to address flexibility needs, the greater the risk of over-generation. If the PMin burden is low, then this will reduce the probability of over-generation. The combination of low load, high wind and solar output, and the need to set dispatchable conventional resources to prepare for the evening net load ramp leads to the possibility of over-generation in the middle of the day. To address this over-generation, the CAISO will need to either curtail other generation resources or increase demand on the system. In both situations it is possible that the state would not meet its RPS goals if the amount of renewable curtailment or load increase is great. If, on the other hand, we do not curtail renewable curtailment and instead decommit dispatchable flexible resources to address the over-generation condition, we jeopardize reliability if we are unable to commit or maintain sufficient dispatchable capacity online for the evening ramp.

## III. IN BALANCING THE LIKELIHOOD OF OVERGENERATION WITH THE STATE'S ENVIRONMENTAL GOALS, THE COMMISSION MUST CONSIDER ALTERNATIVE ASSUMPTIONS ABOUT ECONOMIC RENEWABLE CURTAILMENT

**Q. Please summarize the level of renewable curtailment shown in the CAISO's study results.**

A. Overall, the scenarios tested by Dr. Liu showed curtailments of renewable resources ranging from 26 GWh in the Trajectory scenario without Diablo Canyon to 4,637 GWh in the Expanded Preferred Resources scenario. The Diablo Canyon curtailed the fewest resources because it removes 2,240 MW of baseload capacity from the system. However, as noted above, this also leads to increases in upward capacity shortfalls. The Expanded Preferred Resources Scenario shows the greatest curtailment because it assumes the highest planning reserve margin. This is because it has the most resources included in it, including additional rooftop solar, combined heat and power as well as additional renewable to achieve 40% RPS, and, therefore, has a greater probability for renewable curtailment. Indeed, renewable curtailment was observed in all 12 months of this scenario.

**Q. What assumptions did the CAISO make about achieving the state's RPS goals?**

A. In each scenario, the CAISO assumed that each RPS target was reached. Therefore, any renewable curtailment can be translated into fewer MWs of delivered energy to fulfill the RPS target requirements. As such, both of the Trajectory Scenarios (with and without Diablo Canyon) as well as the High-Load Scenario were less than 0.5 percent under the RPS target for the scenarios. The Expanded Preferred Resource Scenario and 40 Percent RPS scenarios were under a 40 percent RPS target by 6.5 percent and 3.4 percent respectively.

**Q. How did the CAISO model renewable resource economic dispatch?**

A. Based on the Standard Planning Assumptions, Dr. Liu established economic bids for these resources of -$300 to reflect variable operating and maintenance costs. For modeling purposes, this means that it will only be economic to dispatch renewable resources downward if, over-generation leads to -$300 prices. Under these

circumstances, curtailing renewable resources is the last economic solution the CAISO could use to address the over-generation.

**Q. Are there alternative prices that could be used to model renewable resource economic dispatch?**

A. Yes. As noted above, the -$300 bid assumption means that renewable resources are curtailed as a last resort, making this curtailment less efficient and effective. Alternative renewable resource economic dispatch assumptions, such as different bidding prices, might yield different results. For example, if renewable resources are bid in at a zero dollar bid, then the CAISO may find options for meeting its ramping need besides using thermal resources that include a PMin burden. Instead, the CAISO may be able ramp wind and solar resources down slowly, allowing the CAISO to rely on slower ramping resources. Further, assuming a zero curtailment would provide additional insight about the causes and magnitudes of the specific reasons for flexible capacity shortfalls discussed above. However, additional modeling is needed before the CAISO could determine the exact effects of alternative renewable resource economic dispatch assumptions on meeting state RPS goals and flexible capacity needs.

**Q. How does the CAISO's production simulation model handle negative bids for renewable resources?**

A. Including negative bids into the CAISO market means that the resource could be optimally curtailed based submitted economic bids, instead of through manual over-generation procedures, as is done when manually curtailing self-schedules. However, this is the only economic parameter applied to the renewable resources. Many thermal resources for example also have start-up and minimum load costs. This means that even though a thermal resource may have a higher variable cost, as reflected by its bid, PLEXOS may still select a renewable resource to curtail because it is overall more economical to do so, when other cost and commitment parameters are considered.

**Q. Is unlimited economic renewable generation downward flexibility (curtailment) a practical assumption?**

**A.** Not necessarily. I am not aware of any contracts with renewable capacity that allows for unlimited curtailment provisions of the renewable resources identified in table 11 of Dr. Liu's testimony. Further, these contracts may not provide for any economic curtailment. Renewable resources without curtailment provisions are offered into the CAISO as self-schedules. This means that the CAISO can only curtail the output of these resources based on reliability concerns.

**Q. Can you provide specific examples of actual renewable curtailment and economic dispatch quantities from CAISO real-time operations?**

**A.** Year-to-date for 2014, the CAISO has had to curtail a total of 19.39 GWh from renewable resources. On May 1, 2014, the CAISO changed the Participating Intermittent Resource Program (PIRP) bidding rules. This has led to more bids in the CAISO market from renewable resources. Of the total year-to-date curtailment, 17.2 GWh was accomplished through the CAISO real-time market optimization through curtailment of self-schedules and economic bids based on reliability need. The CAISO market optimization engine will only curtail self-schedules when all other economic bids to reduce output are exhausted. .

**Q. How do the curtailments experienced to date compare with those shown in the LTPP studies?**

**A.** Between January 1 and July 31, 2014, the CAISO curtailed a total of 19.39 GWh of renewable energy output. Dr. Liu's results show 153 GWh of curtailment during the same time-frame in the Trajectory scenario and 2825 GWh in the 40 percent RPS Scenario. In other words, using an assumption of unlimited renewable curtailment of the renewable resources identified in table 11 of Dr. Liu's testimony, the CAISO operators would be trying to manage between 8 to 146 times more energy of curtailment and redispatch.

**Q. Should the Commission make system resource flexibility decisions based on studies that assume high levels of renewable generation curtailment?**

A. No. These assumptions may lead to an underestimation of the CAISO's flexible capacity need and, as discussed above may ultimately mask some of the CAISO's flexible capacity needs by allowing the PLEXOS model to curtail renewable resources for a variety of different reasons. Without further analysis it is not possible to determine what the flexible capacity shortfalls actually are. In essence, the assumption of unlimited renewable resources curtailment means PLEXOS will use these resources to address ramping constraints and over-generation constraints. This means it is not possible to make a determination of flexible capacity needs.

**Q. Is economic renewable curtailment a possible operational tool?**

A. Yes, some economic dispatchable capability could be an appropriate operational tool; however, economic curtailment of the scale observed in the 40% RPS or the Expanded Preferred Resource scenarios is not a practical operational tool.

**Q. Please describe the CAISO's operational challenges with dispatching large amounts of renewable generation?**

A. The results imply there are significant operational challenges with an increase in the magnitude of the renewable curtailments. As noted above, CAISO operators would be trying to manage between 8 to 135 times more GWh of curtailment of renewable resources and redispatching other resources in real-time. Another operational challenge of dispatching significant amounts of renewables is the difference between the resource's output at the time of the curtailment and the accuracy of the resource's forecasted output at the time the curtailment event ends. If the forecasted output of the resource has changed since the curtailment began, then the CAISO may be in a situation where it becomes ramp constrained because of the difference. For example, the CAISO may have to dispatch a solar resource down 100 MW with an expectation that, based on the resource's forecast at the time, it would be able to bring the resource back to 100 MW in 3 hours. However, in that time, unexpected

cloud cover may mean that the CAISO can only redispatch the resource to 50 MW. The CAISO would then need to dispatch another resource with a similar ramp rate to make up for the additional 50 MW. The challenges created by this forecast difference can be seen more clearly in looking at the curtailments from Dr. Liu's study. For example, in the 40 percent RPS results show that about 12,500 MW of renewable energy was curtailed in a single curtailment. With curtailments of this magnitude, the CAISO may need to prepare resources to cover forecast errors. This may require additional PMin burden, requiring additional renewable curtailment to prevent over-generation. These uncontrollable events related to the fuel source, inherent in renewable energy, means that it is inevitable that an increase in renewable energy, even if dispatchable, would require the presence of other flexible resources.

## IV. THERE ARE OTHER STUDY ASSUMPTIONS THAT MAY MASK THE NEED FOR ADDITIONAL FLEXIBILITY

**Q. Please describe the CAISO's concerns about the net import assumption.**

A. As noted in Dr. Liu's testimony, the historical low for imports into the CAISO is about 2000 MW. Although Dr. Liu modeled the CAISO as a net importer, there is no assumption that the CAISO maintain a minimum import constraint consistent with historical import levels. Thus, net imports were allowed to go as low as zero MW. However, Dr. Liu's results show that even the net zero net import constraint is binding at some time in all cases, particularly in the 40 percent RPS scenario. There are significant quantities of resources located outside of the CAISO but owned by California load serving entities that are dedicated imports deliveries into the CAISO. For example, California load serving entities own large portions of Hoover and Palo Verde, which provide dedicated imports into the CAISO. This is energy that has been bought and paid for delivery into the CAISO. These dedicated imports increase the possibility for over-generation, particularly in spring months.

As such, before making a determination of flexibility need, the CPUC should consider the impact of these dedicated imports on the risk of over-generation.

**Q. Are the impacts of additional achievable energy efficiency (AAEE) correctly captured in the scenario analysis?**

**A.** No. There is no determination of how the additional AAEE assumptions impact the non-peak load. This creates additional uncertainty about flexible capacity needs. Three of the four scenarios run by Dr. Liu include 5,042 MW of AAEE. The Standard Planning Assumptions require that this AAEE be treated as a reduction to peak load. However, there is nothing that describes how it impacts non-peak load. AAEE that lowers both peak and off-peak load will increase the probability of over-generation, while AAEE that focuses only on peak load may reduce the need for flexible capacity.

## V. POLICY CONSIDERATIONS

**Q. Does the CAISO recommend that the Trajectory scenario be used as the baseline for system procurement decisions?A.**

No. The CAISO views the proposed scenarios as a continuum of possible outcomes. As such, focusing on a single scenario as a baseline is not advisable. The goal of running four scenarios and the "no Diablo Canyon" sensitivity is to create this continuum to inform system need determinations.

**Q. If a baseline scenario is not selected, how can the Commission use the CAISO's study results to make decisions about system needs?A.**

Instead of establishing a baseline scenario, a superior approach would be to establish bookends. Before selecting the bookends, the Commission must first prioritize the different flexibility need measurements reflected by the scenarios. For example, based on the scenarios tested and assumptions used, the Trajectory scenario and the High-Load scenario might provide the bookends if upward capacity

is the highest priority need. However, as noted above the assumption embedded in the scenarios that the CAISO has unlimited renewable curtailment capability of the renewable resources identified in table 11 of Dr. Liu's testimony may mask significant needs for downward and possible upward flexible capacity. As such, the Trajectory Scenario and Expanded Preferred Resources Scenarios may provide the correct bookends if the size of renewable curtailment is the highest priority.

**Q. What policy considerations are raised by these renewable generation curtailment issues?**

**A.** The Commission must consider the tradeoffs of allowing greater economic curtailment and policy mechanisms that support these tradeoffs. As part of the LTPP proceeding, the Commission should consider the magnitude and frequency of curtailment to determine if the observed curtailment at 33% RPS but more importantly at 40% RPS is consistent with overall state policy objectives. Given the results discussed above regarding the magnitude of curtailment and RPS deficiencies in each scenario, forecast error, and the fact that additional un-modeled flexible capacity from the track 1 and 4 authorization, it is may be possible that the RPS targets could still be met in both of the Trajectory scenarios (with and without Diablo Canyon) as well as the High-Load scenario. However, additional studies are needed before a final determination can be made for any the scenarios.

If the Commission views the increased economic curtailment as a viable solution to flexible capacity needs, then contracts, market incentives, and operational practices to support curtailment must be designed to ensure this is an achievable solution. Thus, the nature of the curtailment provisions in the contracts are also important. Many RPS contracts contain curtailment limits. However, generally the curtailment considered is for reliability needs rather than economic dispatch. Self-scheduled renewable resources are done through the CAISO optimization, but are done as a means of maintaining reliable system operation. The curtailment provisions need to be made clear as to how the renewable resources should be made available to the

ISO (self-scheduled or economically bid) and under what conditions the resource can be curtailed. Thus, contractual limitations may need to be reconsidered in light of meeting environmental goals and future reliability needs cost-effectively.

Finally, making resource flexibility decisions assuming high levels of renewable curtailment puts the state's renewable energy goals at risk. Curtailment of resources may mean that the CAISO is able to maintain system reliability without additional flexible capacity resources. However, this is only an acceptable solution if it does not come at the expense of our state environmental policy goals.

If it is determined that the observed curtailment is not consistent with state policy objectives than the proceeding should study the implications and alternatives to curtailment. For example, while increased ability to curtail renewable resources means that the CAISO would require fewer conventional resources to meet flexible capacity needs, it may require the Commission to consider additional renewable energy procurement, ensuring sufficient energy storage capability is available to absorb the over-generation, or crediting a load serving entity for renewable output that would have been produced but for the curtailment to ensure state environmental goals are achieved.

## VI. RECOMMENDATIONS

**Q. What are the CAISO's recommendations for the Phase 1a decision?**

**A.** The CAISO was directed to study full renewable curtailment ability. The CAISO does not expect it will have full curtailment capability for all renewable resources. Additionally, the CAISO believes that existing practices would have to change to achieve net imports below historical levels, to zero net imports, or even further to net export. Lastly, consistent with the Assigned Commissioner Ruling, the CAISO studies did not include 2,315 MW of already approved capacity additions. Therefore, the studies to date are not sufficient to determine the additional capacity

needed to meet flexibility and reliability requirements. Additional studies incorporating alternative assumptions about curtailment of renewable resources, import limitations, and available capacity are needed before the Commission makes a determination of need. Therefore, without additional studies to assess the impact that these critical assumption have on the shortfalls of capacity needs (both upward and downward), as well as the impact of various levels of renewable curtailment, the CAISO does not believe that the results to date are adequate for making a final determination of need to overall capacity or for assessing the CAISO's ability to address flexible capacity needs.

The results show significant renewable curtailment. This may mask the level of need for flexible capacity as it assumes unlimited renewable curtailment of the renewable resources identified in table 11 of Dr. Liu's testimony as the solution to provide flexibility and mitigate over-generation. Without additional studies, it is not possible to identify the specific flexible capacity shortfall that is leading to the curtailment of renewable resources or if curtailment of renewable resources is the optimal solution flexible capacity shortfalls.

Several other tools can provide this capability. The CAISO recommends that the Commission examine in phase 1b the benefits and trade-offs of the range of solutions in the context of meeting state RPS, GHG and other policy goals. Given the range of tools available, the CAISO recommends that the Commission examine in phase 1b the extent that renewable curtailment is used to meet flexibility shortfalls. This conclusion needs to be reconciled with curtailment provisions in power purchase agreements in this or a different proceeding.

There is likely not one single solution that will solve all the observed upward and over generation issues. It is likely that a combination of tools including some renewable flexibility, enhanced regional collaboration, storage, demand response and increase quantity of fast starting flexible resources with low PMin burden will

be necessary. However, before it is possible to start identifying what this mix might look like, additional studies using alternative assumptions about approved capacity additions, import limitations, and renewable curtailment should be conducted. Only then can there be a reasonably accurate picture of the system needs.

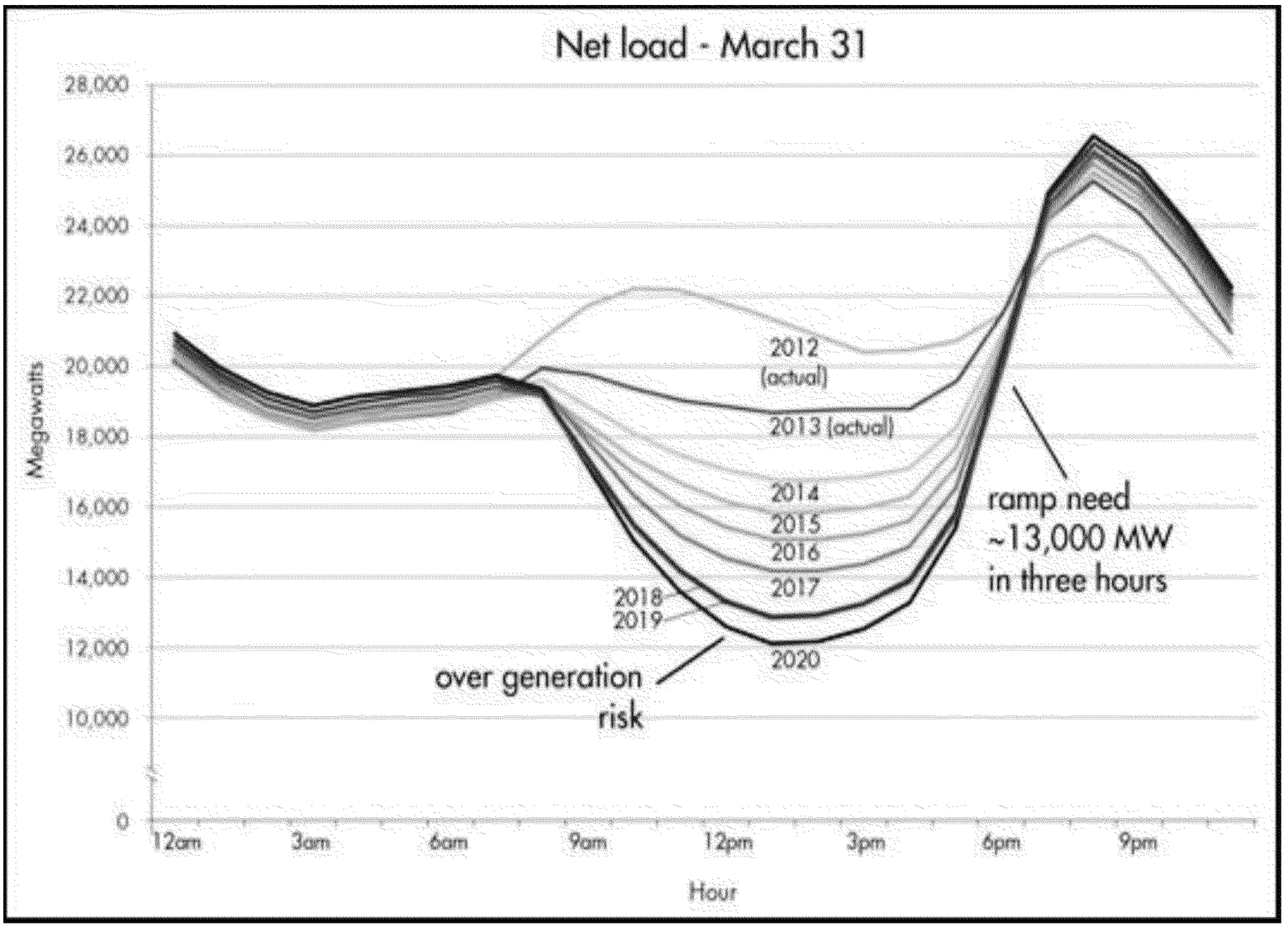
**Q. Does this conclude your testimony?**

**A.** Yes, it does.

ATTACHMENT

California Independent Sytem Operator Corporation

“Duck Chart”


Net load - March 31
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
0
Megawatts
12am
3am
6am
9am
12pm
3pm
6pm
9pm
Hour
2012
(actual)
2013 (actual)
2014
2015
2016
2017
2018
2019
2020
ramp need
~13,000 MW
in three hours
over generation
risk